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Curtiss Eagle Cabin Plane About to Land at Roosevelt Field

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IN the present issue there are printed illustrated descriptions of some of the most recent products of the aircraft industry, all of which will be on exhibition in the forthcoming Aeronautical Show to be held from March 6 to 13 in the 71st Regiment Armory, New York.

Even a cursory examination of the various cabin, mail and sport planes to be exhibited will suffice to convince the reader of the one fundamental truth the Aeronautical Show will proclaim, namely, that the American aircraft industry, far from being in a state of stagnation, is making unceasing progress. Progress will be found in the conception as well as in the execution of commercial aircraft designs. Since the armistice great strides have been made in refining the appearance of airplanes, both as to outline and workmanship, while the peculiar requirements of air transport have led designers vigorously to attack the two outstanding problems of commercial aviation, safety and economy of operation. Safety of operation depends primarily upon engine reliability and this has been attained both by the use of multiple power units and by giving airplanes sufficient reserve power so they can safely operate with the engines throttled down. Although this entails a certain increase in the dead load of the machine, the advantages derived fully compensate for this sacrifice.

On the other hand the importance of cutting down parasite resistance to the irreducible minimum is becoming a generally accepted axiom. In this respect the general cleanness of lines of the latest American airplanes is particularly noteworthy.

That, on the other hand, the well-being of the passenger has not been forgotten, the luxuriously fitted cabin planes and flying boats which will be seen at the Show will conclusively prove.

Taken as a whole, the coming New York Aeronautical Show will afford the public a convincing demonstration of the great silent progress that is constantly being made in aeronautics so as to hasten the advent of aerial transportation.

Stress Analysis

In the stress analysis of the plane, it has become customary to consider two conditions for the calculation of stress, namely, high speed, and low speed. Engineers have used these two conditions so long that they have ceased to question whether they really constitute a sound basis for stress analysis. Arbitrary factors of safety have been assumed for the two conditions, and on the whole, satisfactory results have been obtained in practice.

It has nevertheless, been recognized that the most severe conditions in flight were those due to a flattening out after a dive and on a vertical dive itself, and these conditions do not exactly correspond with the stress analysis methods.

Recent English writers have urged the desirability of modifying the basis of stress analysis, so as to make it correspond more closely to these two worst load conditions, and to make safety factors more uniform throughout the plane.

It is possible to assume a certain factor of safety on the basis of the limiting speed of a vertical dive producing much greater lift on the wings, for a larger angle of incidence after recovery from the dive without appreciable loss of speed. The load in this condition is largely on the front truss, and forms a very reasonable basis for the analysis of the front truss.

The commonly employed high speed analysis bears no relation to the vertical dive itself. On the vertical dive or dive with no lift, there is a moment for the wing section, which is counter-balanced by the load at the tail surfaces, so that a downward load is present on the front spar, and an upward load on the rear spar, and it is for this condition that analysis should be made. This would constitute a distinct departure from standard stress methods.

In dealing with the problem of a consistent factor of safety for the front and rear spars, Mr. Pippard suggests that this could be taken care of in the following way:

The flattening out after a dive may be imagined as taking place with that displacement of the elevators, producing a maximum lift on the horizontal tail surfaces. Since the speed on flattening out after a dive may be taken as very nearly equal to the speed of the dive itself, the force on the tail surfaces may be calculated accordingly, and they should be designed to stand this load. In considering the vertical dive, the stabilizer and elevator may be taken as exercising the same force, and the downward force on the front spar and the upward force on the rear spar calculated accordingly.

There is then a consistent factor of safety throughout. This is a brilliant intellectual conception, and although practical engineers are always unwilling to depart from standard methods of analysis, as long as they work out well in practice, it deserves certain consideration.

The New Curtiss Eagle Cabin Plane

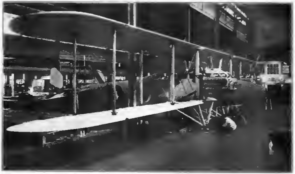
The new Curtiss Eagle cabin plane, which will be one of the important exhibits of the forthcoming New York Aeronautical Show, is built along the basic lines of the 8-place Curtiss Eagle which flew a total distance of 4,400 mi. and carried 943 passengers during a period of two months last fall. It differs from its prototype mainly by its slightly larger dimensions which were adopted in order to take a larger power plant, to increase the radius of action and to carry two additional passengers.

As may be seen from the accompanying illustration, in the new Curtiss Eagle the center engine has been suppressed so as to afford the pilot an unobstructed view forward, the two remaining power units, carried in wing nacelles, consist of the new Curtiss Twelve 400 hp. engine, model C-12, which is an improved design of the engine which carried Roland Rohlfs and the Curtiss Wasp to an altitude of 34,910 ft. last September. This engine is remarkable for its light weight, for it weighs in running order only 675 lbs., or 1.69 lb./b. hp. The new Eagle is designed to maintain altitude with full load of ten people on one of her engines or with both of her engines throttled down to half power. The importance of this arrangement with regard to safe operation is too obvious to require comment, but one may add that by flying the machine under normal conditions with the engines well throttled down the life of the latter will be considerably increased. Maximum power output will be demanded from the engines only for taking off and for special circumstances, such as fighting violent head winds, climbing out of an unfavorable level, etc.

The new Curtiss Eagle has a span of 64 ft. 4 in., an overall length of 36 ft. 7¼ in. and an overall height of 12 ft. 11 in. The net weight is 5,310 lb. and the gross weight 8,890 lb., allowing a useful load of 3,380 lb. which is apportioned as follows —Fuel 1,600 lb., oil 180 lb., pilot 160 lb. and passengers (nine) 1,440 lb.

The maximum speed in horizontal flight, with 800 hp., is 124.5 m.p.h., the minimum flying speed is 56.2 m.p.h. The flying range at cruising speed is 750 mi., or about the distance between New York and Chicago.

By reason of its luxurious appointments and economy of operation the new Curtiss Eagle is peculiarly adapted to the solution of the problems of aerial transport. The passenger cabin, which occupies the forward portion of the fuselage, is equipped with every comfort of modern travel. The equipment includes an electric starter controlled from the instrument board, which does away with the necessity of "swinging the prop."



The New Curtiss Eagle Cabin Plane in Course of Assembly, Fitted with Two of the New Curtiss Twelve 400-Hp Engines

The New Curtiss Twelve Aircraft Engine

The Motor Department of the Curtiss Aeroplane and Motor Corp. has completed for exhibition at the New York Aeronautical Show its Curtiss Twelve, 400 hp. aeronautical motor.

Among the distinctive features of the Curtiss Twelve are its shape, compactness, and adaptability to streamline mounting. The motor is of the Vee type, water cooled, with two banks of six cylinders each, 60 deg. apart. The cubic space occupied by the engine is comparatively small.

The propeller is geared from the crank shaft by a special type reduction gearing which operates the propeller shaft at 1350 r.p.m. The result is not only that a more efficient delivery of power is secured, but that the center of thrust is raised and the propeller centered in the nose of the fuselage. Streamline mounting is accordingly possible, while in ungeared types enlargement of the lower portion of the fuselage to center the propeller gives additional weight and considerable additional head resistance.

The weight of the new Curtiss Twelve is 675 lb. with propeller hub, or less than 1.7 lb. per horsepower. The elimination of rocker arms for intake and exhaust valves by the use of overhead cam shafts and "T" type cam followers, the simplification of the water-cooling system, and the construction of a crank shaft of the seven bearing type which weighs but 49½ lb. have been some of the features responsible for the unprecedented lightness of the motor. Not only is the Curtiss Twelve the lightest 400 hp. stationary engine in use, but it is also considerably lighter than many 300 hp. standard stationary engines.

Side View of the New Curtiss Twelve Aircraft Engine

Tests and data indicate a reliability of operation for the new motor as distinctive as its low weight. Oiling and cooling systems have shown themselves simple and effective in operation. The oiling is of the full pressure feed type. By means of a duplex gear pump with oil leads in both ends of the oil pan the lubricating system becomes effective in all flying positions of the motor. Direct contact of water with the cylinder walls makes for a remarkably satisfactory cooling of the cylinders. Both magneto and carburetors are special developments which have made important contributions to the dependable performances of the motor. Finally, the direct operation of both intake and exhaust valves by overhead cam shafts with specially designed "T" cam followers has simplified the process of valve operation and make it thoroughly dependable, the "T" follower eliminating wear on valve stems with its undesirable possibilities of leakage.

The motor, as a result of a number of the above-mentioned qualities, maintains a high mean effective pressure and has a high volumetric efficiency. It has shown exceptional quality for high altitude flying as well as for general dependability of operation.

One of the characteristics sought in the work of the Curtiss Motor Department with the C-12 was accessibility. All moving parts are enclosed, but are at the same time thoroughly accessible for inspection or repair. The electric self-starter, especially designed for the motor is conveniently situated at the gear instead of the propeller end.

In operation the C-12 shows a gasoline consumption of .508 lb. per horse power hour.

The Thomas-Morse MB-4 Mail Plane

In response to bids for mail planes issued by the Post Office Department which were opened the latter part of June, 1919, the Thomas-Morse Aircraft Corp. prepared a design complying in general with the specifications issued, which stipulated among other things that two or more motors of either the Liberty or Hispano-Suiza type were to be used. They also specified that a minimum of 1500 lb. of mail should be carried at as great a speed as possible concurrent with a reasonable low landing speed, to cope with the small-sized fields from which the postal planes were forced to operate at that time.

Believing that a compact, high-speed plane capable of flying satisfactorily on one motor and carrying the required complement of mail would best represent service to the Postal Department, the Thomas-Morse engineers produced model MB-4.

The Hispano-Suiza model H eight-cylinder motor was selected, and two of these are placed in a center nacelle, one driving a pusher propeller 8 ft. 2 in. in diameter, the other driving a tractor propeller of the same size. Both engines are operated by a single throttle lever which is so arranged that by rotating the handle horizontally, either engine can be independently speeded up or retarded, or if necessary shut off altogether.

The arrangement of two engines in tandem driving centrally has some material advantages over that in which the

Three-Quarter Rear View of the Thomas-Morse MB-4 Mail Plane engines (where two are used) are mounted in the wings, as in the event of one engine failing the entire driving power remaining, operates at a considerable distance from the center of the machine, causing it to drag heavily on the rudder controls. It has been found that in the majority of cases a machine of this type cannot fly for any material length of time on one motor without alighting. This should be entirely overcome in the above-mentioned design, and, although it is true that a small amount of propeller efficiency is sacrificed, it is believed that the gain in reliability and ease of operation will far outweigh any slight losses of efficiency.

Construction

The construction of these planes follows closely the lines of the Thomas-Morse single-seater fighter type MB-3.

The use of three-ply veneer having poplar center and mahogany faces enters largely into the construction, as also does the use of streamlined steel wires, which have an exceedingly

Three-Quarter Front View of the Thomas-Morse MB-4 Mail Plane Fitted with Two Wright-Hispano 300 Hp. Engines

low resistance, and which are used in sufficient numbers to insure adequate strength remaining in the event of failure, through fracture, of any one wire.

The undercarriage consists of two wheels 40 in. in diameter, having 8 in. tires, mounted well forward of the center of gravity, consequently reducing the risk of turning over on soft ground, which has been the cause of numerous accidents in early mail service planes.

Some idea of the compactness of this machine may be gained when it is considered that the span, 45 ft. 6 in., is only 2 ft. more than that of a JN-4 plane, despite the fact that the horsepower of the latter is approximately one-seventh that of the former.

It is estimated that a speed of 122 m.p.h. can be maintained with both motors operating and a speed of 90 to 100 m.p.h. with one motor alone.

In view of the low weight per horsepower carried in this machine, it is indicated that a climb of 9,000 ft. in ten minutes should be obtained with both motors operating and fully 2,000 ft. in ten minutes with one motor alone.

Dual control is provided, a complete set of controls and instruments being located in the nose of each fuselage. The master set, however, controls, as the emergency set is connected to the control members through the medium of rubber shock absorber bands allowing the chief pilot to overpower the efforts of his assistant should necessity arise.

The mail is carried immediately aft of the pilot and passenger cockpits in the side fuselages, the main gasoline tank being located in the center nacelle and a gravity service tank in the leading edge of the top wing.

A single radiator placed in the center portion of the top wing provides cooling for both motors. This in turn is provided with an adjustable shutter for controlling the temperature to a nicety, according to altitude and outside temperature conditions.

The main planes, which are composed of seven wing sections, have a chord, top and bottom, of 8 ft. 10 in. and a total surface area of 645 sq. ft. The span of the top plane is 45 ft. 6 in. and that of the lower 42 ft. 8 in., the aspect ratio thus being 5.15 and 4.62 respectively. A RAF-15 wing curve is used. Both planes are set at an average angle of incidence of —1/3 deg., dihedral of 178 deg., gap of 8 ft. 3 in. and no stagger.

The wing structure is built up of spruce spars and plywood ribs, internally braced by tierods. The interplane struts are laminated spruce and mahogany, and have a fineness ratio of 4. Both lift and landing wires are streamline tierods.

The fuselage is composed of ash and spruce longitudinals, braced by tierods, and of spruce and mahogany crosspieces.

Control is of the stick type, ailerons controls being operated by single tierods, rudders and elevators by double tierods. The area of the control surfaces is as follows: Ailerons (fitted to upper plane only), 44 sq. ft., elevators, 34 sq. ft., rudders, 22 sq. ft., horizontal fins, 16 sq. ft., vertical fins, 4 sq. ft.

The MB-4 weighs empty, fully equipped with instruments, 3554 lb. The instruments include two 20,000-ft. altimeters, two speed indicators, two tachometers, a gasoline shut-off valve, two fire extinguishers, two oil thermometers, two water thermometers, gas overflow, compass, clock, map case, primer and starting magneto. The useful load, including fuel load, is 2010 lb.

Specifications

Overall Dimensions.—Length, 25 ft. 5 in., spread, 45½ ft.; height, 11 ft.

Performance.—High speed, 122 m.p.h., low speed, 53 m.p.h., climb in 10 min., 9000 ft. Factory of safety not less than 6 fully loaded.

Weight and Lift Data.—Total weight (loaded), 5564 lb., area lifting surface (including ailerons), 645 sq. ft.; loading per sq. ft. of lifting surface, 8.65 lb., required horsepower, 680, weight of machine per horsepower, 8.2 lb., angle of incidence (average) at high speed, —1/3 deg., angle of incidence (average), at low speed, +12 deg.

Power Plant.—Hispano-Suiza Model H; rated horsepower, 300, weight per b.h.p., 2.04 lb., r.p.m., 1800, fuel capacity, 140 gal., fuel consumption, .54 lb. per b.hp., oil capacity, 10 gal., oil consumption, .03 lb. per b.hp.

Propeller.—Two 2-blade tractors, weight, 27 lb., diameter, 9 ft. 2 in., pitch, 7 ft. 5 in., r.p.m., 1800.

Fokker Airplanes Arrive

Twelve Fokker pursuit airplanes, with 260 hp. Mercedes engines, have been received at the Aviation Repair Depot at Indianapolis, Ind. These machines were turned over to the United States by Germany in accordance with the terms of the armistice.

The Glenn L. Martin Torpedo Plane

Undercarriage of the Glenn Martin Torpedo Plane, with a 1560-Lb. Regulation Navy Torpedo in Place

The Glenn L. Martin torpedo plane, the first machine of its kind built for the United States Navy, successfully passed its acceptance tests on Feb. 11, 1920, at Cleveland, Ohio. The firm is now engaged in the production of the remainder of the order for ten machines of this type, the introduction of which will open the way to new fields in naval warfare and promises eventually to render the present-day torpedo boat destroyer obsolete. Owing to the great speed and comparatively small size of torpedo planes, these machines will be capable of getting within firing range with a much smaller chance of being hit than has ever been possible with a torpedo boat; hence the offensive value of the torpedo will be greatly increased, whereas if the torpedo plane is hit the loss of life and material will be almost insignificant as compared with a destroyer, which carries a complement of some hundred men.

The Martin torpedo plane has the same general specifications as the well-known Martin bomber, from which it differs mainly by some minor details in design and equipment made necessary by the requirements of naval use. The span is 71 ft. 5 in., the overall length 46 ft., and the overall height 14 ft., the power plant consists of two high-compression Liberty-Twelves, fitted in wing nacelles and driving tractor airscrews. The design of the main planes is "square" all around, there being no sweepback, stagger or dihedral.

One of the main points of difference in the new plane is incorporated in the landing gear, which has been divided in the middle so as to permit the dropping of a Navy regulation torpedo of 1,560 lb., which is carried in a cradle underneath the fuselage. As the Martin torpedo plane is intended for work from shore stations or from the deck of aircraft carriers, it is not fitted with floats, but carries in addition to its standard landing gear an emergency flotation gear in the form of air bags, which can be inflated from a compressed air tank. Thus, when the machine has fulfilled its mission it alights in the lee of its mothership and is hoisted on board. For this purpose "sky hooks" are provided on the upper main plane.

Completely equipped for naval service, the Martin torpedo plane carries in addition to one 1,560 lb. torpedo, two machine guns with ammunition, four hours' fuel and a crew of three men. The contract performance, which called for a speed of 105 m.p.h., and a climb of 4,000 ft. in 10 min., was

Three-Quarter Rear View of the Glenn Martin "Transport" Cabin Plane largely exceeded upon trials. Piloted by Eric Springer, and with the full load above specified, the machine left the ground in 14 sec., and reached 4,000 ft. in 6 min and 5,860 ft. in 10 min. After completing the climb test Springer brought the plane down to a 1,000-ft. level and proceeded to make two trips over a measured mile course for the speed trial. His two trips averaged 112.25 m. p. h. which, when proper allowance is made for altitude, will probably bring up the speed at ground level to 114 m. p. h.

The trials of the machine were checked on behalf of the Navy by Comdr. N. B Chase, U. S N, and Lieut. E. B Koger, U. S N, who acted as flying observers, and by Lieut. J. F. Fitzpatrick, U S N, and Ens. G. H McCarthy, U. S N, from the ground.

The Orenco Type F 4-Seater Tourist Plane

The Orenco four-place tourister's most attractive feature is the double side-by-side seating arrangement that eliminates the feeling of isolation and lack of companionship usually associated with all planes of the tandem type. The pilot and his three companions enjoy the convenient placing that gives each security and comfort and the congenial closeness it promotes. Although shrewdly designed to be as compact as possible, affording the maximum protection against the weather, the two upholstered cockpits are easily accessible.

Two passengers in the forward seats have plenty of room for freedom of movement, and for their protection an automobile type wind shield is mounted forward of the cockpit The pilot and his companion in the rear cockpit are provided with two separate and complete controls that enable either to guide the plane By this arrangement the pilot can observe just how the plane is being handled and can instantly resume control in an emergency or near the ground. In this manner the average person can quickly acquire the art of piloting the machine The sportsman can give his friends a better appreciation of flight's mystery for they can actually see his movements and the corresponding maneuvering of the aeroplane Whether it is for the novelty or as a practical business proposition, the side-by-side seating arrangement has many definite points of superiority over the old tandem plane

The nicely streamlined body is pleasing in appearance and its finish is equal to the finest automobile both in attractiveness and serviceability Parts are easily reached for making adjustments, repairs and installations Main wings are identical in plan, wing struts are all similar and interchangeable with one another, which means that only a limited number of spare parts are necessary. Standardization has been carried out wherever a duplication of parts would effect a saving, for new parts and fittings can always be promptly procured with the assurance of perfect fit

General dimensions of the Type F are as follows Span of both upper and lower wings, 36 ft. Length, 24 ft. 10 in. Wing area, 355 sq ft , as the weight of the plane fully loaded is 2300 lb., the loading per sq. ft. is 6 48 lb. With a 150-hp. Wright-Hispano engine, the power loading is 15 2 lb./hp

Carrying a pilot, three passengers, baggage and fuel totaling 955 lb in weight, the Type F can cover a distance of about 290 mi at the rate of 89 m.p h. For shorter trips less fuel may be carried which will permit taking on additional luggage, etc. The gasoline tank under the forward seat has a capacity for 250 lb of fuel; it is located at the center of gravity, where a lightening of the fuel load does not alter the balance of the machine. All the seats are located close to the center of gravity and whether carrying only the pilot or its full capacity of four persons, proper flying trim is always inherently maintained

In taking off for flight the machine leaves the ground after a run of about 350 ft., and in landing comes to a complete rest after a run of 300 ft. With full load an altitude of 5000 ft is reached in 9 min , but with a lighter load the climb rate is much more rapid. Near the ground the speed range is 96-45 m.p h The slow landing speed is especially conducive to well chosen landings, and this, with the wide wheel track and generous shock-absorbers assure landings which neither strain the machine nor jar the occupants, even in fairly uneven fields The large control surfaces and their ease of operation facilitate positive precision in all maneuvres

Three-Quarter Front View of the Orenco F Tourist Plane

The L. W. F. Owl Freight Plane

The Owl freight plane was designed and built by the L. W. F. Engineering Co., principally to satisfy the need for adequate mail transports in this country It is a land machine of 1200 hp. with a useful load of 7,600 lb

The design is of the twin fuselage and center nacelle type, and by installing one of three different nacelles, it may be used for transporting mail or express, passenger carrying, or night bombing.

Construction

The outstanding features that identify this machine among others, are the monocoque fuselage and nacelle, the intercommunicating gasoline system and the fire extinguishing system. The wing construction is of the Pratt truss type and consists of three upper and three lower panels of 11 ft chord and equal spans with an 11-ft gap. Each wing is equipped with balanced interchangeable ailerons. Ribs are built up first and then slipped over the beams which are built up of four pieces, thus forming a hollow box section, the top and bottom are of spruce and the sides of birch. The internal wire bracing is double and of No. 8 solid piano wire and 3/16 in hard cable All external wire fittings are applied directly to the beams and project through the covering

The fuselages and the nacelle are supported between the upper and lower planes on tubular struts which are thoroughly streamlined. A 12 cyl., high compression Liberty engine is streamlined into the nose of each fuselage and the nacelle, each engine driving a tractor propeller. The main load and crew are carried in the nacelle, while each fuselage carries its complete power plant and has a small auxiliary compartment for excess mail or cargo

Each power plant is complete within its respective fuselage or nacelle and consists of a 12-cyl. Liberty engine driving a 6 ft. 6 in. tractor and equipped with Splitdorf ignition, electric starters and compression release. The radiators are above the motors, directly in the blast of the propeller and equipped with individual shutter controls.

The tail is of the biplane type, attached to the rear end of the two fuselages. It consists of two double cambered horizontal stabilizer planes, superimposed, with elevators attached and a fin on the top of each fuselage followed by a balanced rudder. A third balanced rudder is installed midway between the two

The landing gear is of the six-wheel, two-axle type, with the outer two wheels side by side directly under the center of each fuselage and the other two wheels spaced equally between. The landing gear is so placed that when landing, the center of gravity falls sufficiently far back of the wheels to prevent any tendency to nose over.

Specifications

General Dimensions.—Both upper and lower planes have an overall span of 105 ft. and a chord of 11 ft The upper plane has an angle of incidence of 4½ deg. and the lower plane 3½ deg The interplane gap is 11 ft., there is no stagger, sweepback or dihedral The wing curve used is the U. S A. No. 6 Each plane, excluding the ailerons, has a surface area of 1,000 sq ft., and each of the four ailerons is 50 sq ft in area, the total wing area is thus 2,200 sq ft The surface areas of the empennage are as follows horizontal fins (upper and lower), 174 4 sq ft , vertical fins (two), 28 sq ft , rudders (three), 78 9 sq ft

The overall length of the airplane is 53 ft. 9½ in. and the overall height 17 ft 8 in.

Weights and Loading.—The machine weighs empty 12,600 lb and fully loaded about 20,000 lb ; the useful load is thus 7,600 lb. The wing loading is 9 1 lb./sq. ft. and the power loading 16 6 lb./b.hp

The L. W. F. Freight Plane "Owl" in Course of Assembly

The L. W. F. Butterfly

The L. W F Butterfly sport airplane is one of the smallest flying machines that have been produced in this country. In this design an effort has been made to produce a machine that would combine good flying qualities with low cost of production and upkeep, so as to be particularly attractive to the aviator-owner.

The Butterfly is a one-place rigid truss monoplane of very pleasing appearance, which is due to the clean lines of its design The L.W F. Cato horizontal opposed cylinder engine happily blends into the nicely streamlined fuselage of plywood, leaving only the cylinders exposed to the air, while the wing truss and landing gear members, all steel tubes, are so arranged as to create a minimum of head resistance. The wings, ailerons and tail surfaces are easily detachable and many of the parts are interchangeable, thus facilitating repair The wings are attached flush with the top of the fuselage so that the pilot has an unobstructed view forward, while at the same time he can watch the ground sideways through the split of the wings on either side of the fuselage.

Specifications.—The wings have an overall span of 29 ft. 9 in. and a chord of 84 in , which gives a supporting surface of 176.5 sq. ft., including two ailerons of 10 5 sq. ft. each. As

Three-Quarter Rear View of the L. W. F. Sport Plane "Butterfly"

the gross weight of the machine is 918 lb., the wing loading works out at 4.9 lb./sq. ft. The wing curve is a Cato-4.

The overall length is 19 ft. and the overall height 5 ft. 10 in. The areas of the tail surfaces are as follows: elevators (each), 5.5 sq. ft., stabilizer, 8 sq. ft., vertical fin, 3.75 sq. ft., rudder, 5.5 sq. ft.

The power plant is an L. W. F. Cato 2-cyl. horizontal opposed air-cooled four-stroke type engine. It has a bore of 5 in. and a stroke of 6 in., with valves in the cylinder heads, and develops 72 b.hp. at 1,825 r.p.m. The area of the piston head is 19.635 sq. in., the swept volume 117.88 cu. in., the piston displacement 235.62 cu. in. and the total volume, including clearance volume, 152.97 cu. in. The compression ratio is 4.33 to 1. The engine weighs in running order 154 lb.

The net weight of the Butterfly is 595 lb. and the useful load 383 lb., which gives a gross weight of 918 lb. The power loading is 13.5 lb./b.hp.

The high speed in horizontal flight is about 72 m.p.h. and the low speed is estimated at 22 m.p.h. The climb is 4,800 ft. in 10 min. and the radius of action at full throttle 6 hr.

The Farman Sport Airplane

The Farman Sport airplane, which is illustrated herewith, is the latest of the numerous successful products of the veteran airplane builders of France.

This machine has been designed with the distinct view to providing a touring airplane which would be low priced in initial outlay and economic in operation. As a result the Farman Sport airplane embodies constructional features which permit rapid production and easy repairing.

The wings are of the square type, that is, they have neither sweepback nor dihedral, and the wing tips are straight sided. The overall span is 23 ft. 3 in. and the overall length 19 ft. 11 in. The interplane bracing consists of four vertical center section struts and two N-struts near the wing tips. Ailerons are carried on the upper plane only.

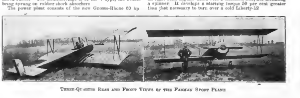
The fuselage is of the four-longeron type, with wooden cross pieces and wire bracing. The empennage consists of a horizontal stabilizer, an unbalanced elevator and an unbalanced rudder. The undercarriage is of the V type, the wheels being sprung on rubber shock absorbers.

The power plant consists of the new Gnome-Rhone 60 hp. rotary air-cooled engine, which consumes 3 gal. per hour and gives the airplane a high speed of from 80 to 85 m.p.h. The low speed is about 30 m.p.h., the take-off 40 yds. and the cruising radius 3½ hr.

The Farman Sport plane weighs empty 460 lb. and fully loaded 900 lb.

Portable Engine Cranker

A portable engine cranker designed and built under the supervision of the Equipment Section, Engineering Division, McCook Field, was successfully demonstrated Dec. 18, 1919. The design allows for the cranking of engines mounted in various airplanes, ranging from the Curtiss training plane to the Martin bombing types, on rough and uneven ground. The outstanding feature of this cranker is that it will accommodate all right-hand engines fitted with a standard hub, not mounting a spinner. It develops a starting torque 50 per cent greater than that necessary to turn over a cold Liberty-12.



Three-Quarter Rear and Front Views of the Farman Sport Plane

The Model J-2 Mail Plane

General.—This mail plane was designed and constructed with the distinct idea of permitting the use of as many parts of the standard DH-4 as possible in the construction of an economical twin-engine machine. Such parts as were used were not changed in any manner excepting reinforcements where necessary.

The J-2 is a medium size airplane of 420 hp. and is characterized by two superimposed main planes of equal span, a central fuselage and two engine nacelles between the wings. This construction helps to eliminate fire risk, as no fuel is carried in the wing nacelles, and it also simplifies the loading and unloading of the mail, since the mail compartment is located in the nose of the fuselage and is thus readily accessible.

Specifications.—The J-2 has a span, top and bottom, of 56 ft. 9¾ in., an overall length of 31 ft. 2 in., and an overall height of 11 ft. Fitted with two Hall-Scott L-6 engines, the machine carries besides the pilot and fuel for 4 hr. flight, a mail load of 650 lb., which represents a useful load of 1.763 lb., or 31.8 per cent of the gross weight, the latter being 5,550 lb.

Three-Quarter Front View of the Model J-2 U. S. Mail Plane, as Originally Fitted with Two Hispano-Suiza 180 Hp. Engines

The performances are as follows: high speed, 105 m.p.h. at ground level, 104 m.p.h. at 4,500 ft., 102 m.p.h. at 9,000 ft., and 98 m.p.h. at 13,500 ft.; low speed at ground level 53 m.p.h.; climb, 4,500 ft. in 5 min. Ceiling 18,000 ft. Full speed endurance 4 hr., including climb to 5,000 ft.

Main Planes.—The wing structure is composed of the regular DH-4 planes in the outer panels and of special 12-ft. center panels which have the outer connections so designed as to permit the use of the standard DH-4 fittings. The ribs in the center panel are of general DH-4 type, special box webs and hollow compression struts are used, however.

The engine struts and the wing struts used in the center section are of mild seamless steel tubing, excepting the four fuselage struts, which are of spruce. All exposed steel struts are carefully faired with balsawood. The minimum safety factor of the wing structure is 6.

The wing curve is the R.A.F. 15, with a chord of 5 ft. 6 in. and an aspect ratio of 10.3. The wings are set at an angle of incidence of 3 deg., with the outer panels having a dihedral of 3 deg. There is no stagger, sweepback or decalage. The interplane gap is 5 ft. 8 in.

The main planes, not including the ailerons, of which there are four, have a total area of 533.44 sq. ft., and each aileron has an area of 17.64 sq. ft. The total supporting area is thus 604 sq. ft., which with the gross weight of 5,550 lb. gives a wing loading of 9.18 lb. per sq. ft.

Fuselage and Nacelles.—The fuselage is the standard DH-4 fuselage with the following modifications: The Liberty-Twelve has been removed and the resulting free space remodeled into a mail compartment, the pilot cockpit has been transferred to the rear gunner's position and a larger gasoline tank has been fitted in the place of the old fuel tank and the former front cockpit. The rear part of the fuselage is strengthened so as to support adequately the new empennage.

The wing nacelles consist simply of an engine housing supported by wing struts. The engine is carefully enclosed in a housing of aluminum sheeting so as to reduce head resistance and to protect the engine from inclement weather.

Power Plant.—The power plant consists of two Hall-Scott L-6 vertical 6-cyl. water-cooled engines, each of which develops 200 hp. at 1,600 r.p.m. The airscrews are tractors of 8 ft. 8 in. diameter and 6 ft. 6 in. pitch; their rotation, as viewed from the pilot's cockpit, is clockwise. The power loading is 13.87 lb. per b.hp.

The radiators are located directly above and in front of each engine, that is, in a position which assures the maximum air blast from the propellers. Specially designed shutters, which are controllable from the pilot's cockpit, permit to vary the cooling area of the radiators. The latter are incidentally designed with excess cooling surface, so that the machine may fly on one engine without risk of overheating, while the shutters take care of excess radiation when flying on both engines.

The requisite gasoline, oil and engine controls are all operated from the pilot's cockpit. The fuel and oil connections, as well as the control leads, are carried from the wing nacelles to the fuselage through streamline tubes. The fuel is fed primarily by air pressure, which is maintained by a hand pump. In case of failure of the pressure feed system a gravity system is provided. For this emergency a single gravity tank supplies both engines and contains sufficient fuel for the operation of both engines at full speed for one half hour.

A transmission thermometer on the instrument board indicates the water temperature of each engine.

Tail Planes.—The tail planes of the J-2 differ from those of the DH-4 in that the area of elevators and stabilizers is greater and that a large single balanced rudder is employed. The stabilizer incidence adjustment gear of the DH-4 has been removed and the stabilizer fixed at neutral incidence. The whole empennage is reinforced by means of streamline steel tubes and cables.

The two horizontal stabilizers have a total area of 38.42 sq. ft. and the two elevators a total area of 24 sq. ft. The vertical fin has an area of 6.81 sq. ft. and the rudder 20 sq. ft.

The tail skid is of the standard DH-4 type.

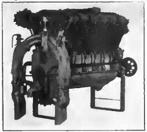
Landing Gear.—A special landing gear is one of the features of the J-2. This consists of the regular L-W-F landing gear for single engine airplanes. A pair of steel tube struts are fitted to the outer ends of the axle and are carried up to the under side of the lower wings to a point where the engine struts abut against the front wing spar. Suitable shock absorbers are fitted to these struts so as to permit the axle to move up and down. Two standard wheels are mounted on each end of the axle inside of the tubular struts. Both steel tubes are carefully streamlined.

The whole landing gear is so placed that on alighting the center of gravity falls sufficiently aft of the wheels to prevent any tendency to nose over. The tread of the wheels is 6 ft. 2 in.

Controls and Instruments.—The flight controls are of the Dep type, with control lever and front bar. The spark levers, throttles, radiator shutter levers and other controls are conveniently arranged within the pilot's reach. An instrument board bearing an individual set of instruments for each power unit, besides those required for general control, is mounted in the cockpit.

The Packard Fuelizer

The failure of a cold engine to respond to the throttle has been responsible for a great many accidents in landing and at all times is an ever present menace to the most skillful pilot. It must be remembered that even in midsummer it is intensely cold at altitudes of 15,000 ft. and over. When a pilot glides down from some such altitude to make a landing his engine, being throttled down, cools off very rapidly and at a critical time just previous to landing, when he may need a sudden spurt of power to take him over some hitherto unseen obstacle or to



Packard Model 1-A-1650 Engine Equipped with Fuelizer

correct an error of judgment, the engine may fail to "take the throttle." This leaves the pilot helpless and a bad landing will inevitably result, sometimes with serious consequences.

When Col. J. G. Vincent, vice president of engineering, Packard Motor Car Co., and co-designer of the Liberty engine, left the service of the Army at the close of the war, he realized that this possibility of engine failure at a critical time was the most serious handicap commercial aviation had to face, and he consequently bent all his energies towards solving this difficulty. At the same time the Packard Co. had a somewhat similar problem to face in the automobile field with the low grade fuels which the enormous growth of the automobile industry compelled us to use. These heavy fuels were threatening the very foundations of the industry, engines were hard to start and harder to run in cold weather. Spark plug fouling, carbonizing, faulty lubrication due to kerosene diluting the lubricating oil, and greatly increased wear and tear of the engine were the direct result of this fuel situation. This was a critical state of affairs, and recognizing the similarity of the problems faced by the airplane engine, the Packard Motor Car Co. devoted its extensive resources to the dual problem, and as a result of months of intensive day and night experimental work the Fuelizer was evolved.

The Fuelizer forms an adjunct to the carburetting system of an engine and has the duty of supplying exactly the amount of heat required to vaporize the fuel under all conditions. There had been many attempts to do this, but they had all failed to accomplish what was really required. Maximum heat under low throttle conditions and minimum heat under wide open throttle conditions are the fundamental requirements, and the Fuelizer accomplishes this perfectly by very simple means. The Fuelizer consists of a burner in conjunction with a miniature carburetor and automatically regulates the amount of heat supplied to the intake header without a single moving part.

This essential characteristic of proper heat control is arrived at by taking advantage of pressure conditions on either side of the engine throttle. A by-pass or shunt is provided around the throttle, and this passage supplies the mixture of air and gasoline to the burner. After combustion has taken place in the burner the burnt gases join the main mixture which has gone by the engine throttle and an intense heat is imparted to the mixture. As the throttle is gradually opened there is less and less tendency for the mixture to take the by-pass through the burner, and consequently the burner gradually goes out of action and at wide open throttle it is supplying no heat at all to the mixture, which is exactly the result aimed at.

The influence of the Fuelizer on the engine is immediately apparent and tests run day and night on the road under extreme climatic conditions varying from 100 deg. in the shade to 10 deg. below zero have proved the claim that the Fuelizer makes the engine independent of seasonal changes, allows the use of much heavier fuels than we are using today with far better results than we have been accustomed to in the past, and removes all possibility of spark plug fouling, crankcase dilution and premature wearing out of the engine.

The Packard 1A-1650 aircraft engine, which is herewith illustrated and which will be exhibited at the forthcoming Aeronautical Show in New York, will give the public the first opportunity of inspecting the application of the Fuelizer to an aircraft engine. In Colonel Vincent's estimation the Fuelizer constitutes the final step towards preventing engine failure in the air, which should do much to popularize commercial aviation.

A Letter

Editor, Aviation and Aeronautical Engineering—I have read with much interest the article on Aeromarine Aerial Mail Delivery System, by Paul G. Zimmerman.

Why not deliver this mail by allowing it to dangle from the end of a shock-absorbing rope and have a long cat-o-nine tail of shock-absorbing cord attached to the mail bag so that the cat-o-nine tail would engage the rigging of the vessel, and the aviator, as soon as he felt the drag of the shock-absorbing rope, showing that the burden has so engaged the rigging, would cast loose his shock-absorbing rope by any device suitable for this purpose.

I have myself picked up burdens in flight up to a weight of 155 lb. with the help of a shock absorbing rope, and know from experience that an ordinary small airplane can carry 155 lb. in the form of two big bags at the end of a shock-absorbing rope without any serious inconvenience, for I picked up this weight from a moving sea-sled on October 3, 1918, soaring to a height of 150 ft., and then my assistant disengaged the shock-absorbing rope and we recovered the bags and the rope by means of a buoy attached to the upper end of the rope.

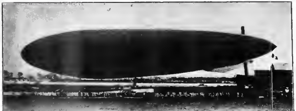
A still simpler method is to throw the bag, releasing by a suitable catch, into a large elastic net, hanging to four masts by shock-absorbing cords. Apparatus suitable for this purpose was prepared by me at Hampton Roads and is probably now available for the Navy to try out this plan if they are willing to do so.

These shock-absorbing ropes have a total elongation of 400 per cent before they part, which makes up the strain due to horizontal acceleration, whether in picking up a burden or depositing it. Of course, in the latter case the acceleration is a minus acceleration, and in either case the maximum strain on the rope due to horizontal acceleration will be proportionate directly to the weight and to the square of the velocity of the airplane relative to the burden in picking up a burden, or of the burden relative to the net in which it is caught in depositing a burden.

Godfrey L. Cabot.

The Zodiac Airship ZD-US 1

By John Jay Ide
Lieut. (j. g.) U. S. N. R. F.



General View of the New Naval Airship ZD-US 1 During Her Trials in France

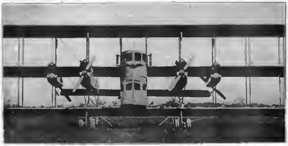
During the war six airships were delivered to the United States Navy by the French government. At the signing of the armistice six additional airships which had been likewise ordered by our naval authorities were under construction. After the cessation of hostilities work was continued on only three of these craft of which the first to be completed, built by the Zodiac Co. and named the ZD US 1, had very satisfactory tests preparatory to being shipped to America where it has since arrived.

This class of airships, of 326,000 cubic feet capacity, was designed to carry the very heavy armament of a 75 mm. (2.95 in.) gun forward, a machine gun aft, 2 bombs of 260 lb. and 4 of 110 lb. In order to provide sufficient comfort for the crew of ten men in carrying out patrols of long duration, the engines were placed as far away as possible from the navigating room, which is entirely enclosed by windows. Another improvement over earlier French designs lay in the position of the wireless telegraph installation, which instead of being at the stern of the car was placed in the navigating room.

The 75 mm. gun is placed in the extreme bow of the car. In order not to interfere with the field of view ahead of the pilots, the gun platform is dropped two feet below the level of the floor of the navigating room.

The gun, by far the most powerful used successfully on aircraft, fires a 13-lb. projectile with an initial velocity of 1300 ft. per sec. The recoil is between 4400 and 6600 lb. The

Car of the ZD-US 1. Note 75-Mm. Gun Mounted Forward and Bomb Chutes Aft of the Port Engine



Center Portion of Italy's Latest Cabin Plane, a 40 Place Caproni
(C) *Kodel & Herbert*

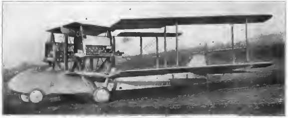
problem of making the car and suspension strong enough to take the recoil while preserving the requisite lightness of construction presented great difficulties, particularly in view of the fact that in an anti-submarine attack it may be necessary to fire the gun vertically downward. The measures taken to absorb the shock of the recoil have proved absolutely satisfactory.

Immediately aft of the gun platform is a very large and comfortable navigating room. The view from this room is exceedingly good, as not only are there windows all around the sides, but transparent panels are also placed in the overhang beyond the gunwale of the car, giving a satisfactory downward view without having to open the windows. In addition there are large transparent panels placed in the roof.

The airship is equipped with two *Renault* twelve cylinder water-cooled V type engines giving 220 hp. each at 1300 r.p.m. The engines, mounted outboard on pylons, are provided with electric self-starters. The two-bladed propellers of 11.4 ft. diameter are driven direct.

The ballonets are kept inflated with air by means of scoops fitted on each side of the car placed in the slipstreams of the propellers. An 8 hp. auxiliary motor operates a blower for use when the engines are stopped.

The characteristics of the ZD-US 1 are as follows: Type, nonrigid. Rigging, external. Length of envelope, 262.5 ft. Diameter, 50.2 ft. Width over fins, 50 ft. Overall height, 72.2 ft. Length of car, 54.7 ft. Width of car, 4.9 ft. Maximum speed 50 m.p.h. Cruising speed, 40 m.p.h. Endurance, 14 hr. at full speed and 30 hr. at cruising speed.



The Airco-10, a Folding-Wing Bomber of the R. A. F. Which Is to Be Built in Canada by the Aircraft Manufacturing Co. of Canada

Short Sporting Type Seaplane

Front and Side Views of the Short Sporting Seaplane with Wings Extended

The Short sporting type seaplane is designed as a general utility machine. The functions it will fill are numerous, and for convenience can be described under two headings:—military and commercial.

Military.—Accommodation is provided for pilot and three passengers. The seating arrangements are:—the two front seats tandem fashion and provided with dual control, the rear seats side-by-side. Thus it will be possible to carry out tuition work not only in flying, but in gunnery, wireless, photography and bombing. For these latter, pilot instructor and pupil can be accommodated, plenty of room being provided in the rear seats for wireless, guns or cameras. The view from the rear seat is excellent, and good arcs of fire are obtained. For the above work the machine is fitted with a 160 h.p. Beardmore engine, as a high performance is not required and economy in fuel is very necessary.

Commercial.—For tuition, passenger work or the transport of small quantities of freight the machine is most suitable, and will fill the requirements of:—

(1). The sporting man who wishes to purchase a machine in which he can learn to fly and take his friends for flights.

(2). The experienced pilot who is desirous of running a passenger carrying and tuition machine at a seaside resort as a commercial undertaking.

(3). Companies owning factories, i. e., buildings on rivers and lakes who require a quick method of transport for their officials, and for light parcels and mails.

The machine is designed on the standard lines of the well-known Short seaplanes, and therefore embodies all those important details of construction which have been evolved during seven years of hard experience. Particular attention has been paid to making the machine safe in landing and getting off the water, and to achieve this object some reduction in the possible speed attained of a machine of this size and power has been made.

A valuable feature in the design is that the machine is made to fold into small compass by means of the Short Patent Folding Wing System which permits the machine being housed in a shed of very small dimensions. The actual size of the machine folded is 15 ft. wide x 33 ft. long x 12 ft. high.

To beach the machine an axle is passed through prepared holes in the boats, wheels are attached to each end, and the machine can then be handled by two or three men with great ease. To assist handling on the ground a detachable wheel is fixed to the tail post, thus allowing the machine to be swung round or maneuvered in its shed with the greatest facility.

The floats of the machine are combining great strength and rigidity with lightness. A feature of the design is the curved bottom of the floats. This ensures quick get-away, and minimizes the shock of landing, but is of particular importance when beaching the machine. Owing to the curvature, the bottom of the float does not touch the ground, all the wear and tear being taken by runners which are attached to the sides of the floats. These act like skids and are shod with metal to give greater durability.

Specifications.—The Short sporting seaplane has a span, top and bottom, of 44 ft. an overall length of 33 ft. and an overall height of 12 ft. The wing area is 550 sq. ft. and the wing loading 62 lb. sq. ft. Fitted with a 160 hp. Beardmore engine the machine has a high speed of 83 m.p.h. and carries sufficient fuel and oil for 3 hr. flight. The climb is 10,000 ft. in 35 min. The weight empty is 2,095 lb. and fully loaded 3,100 lb.

Rear and Front Views of the Short Sporting Seaplane with Wings Folded

Resume of Wind Tunnel Tests of Airship Envelopes

By Comdr. J. C. Hunsaker (C. C.) U. S. N.

Upon the termination of the recent printers strike there was published in the Dec 1, 1919, issue of Aviation and Aeronautical Engineering *an article of the above title. As various printing errors occurred in this article owing to hurried proof-reading, a corrected version is reprinted herewith.*—Editor.

A large number of stream-line bodies have been tested in the 8 ft. 8 in. wind tunnel of the Washington Navy Yard, and without going into details of these tests certain conclusions of general interest may be given.

The resistance in a relative wind velocity V is expressed by the formula

$$R = C \frac{\rho}{g} (\text{Volume})^{2/3} V^2$$

where $\frac{\rho}{g}$ is the mass density of the air and C, a coefficient which is nearly constant. The form having the lowest value of the coefficient C has the least resistance for a given volume or buoyancy. The expression was first proposed by Prandtl and is in general use.

In the course of tests on various forms the coefficient C has been found to vary as a function of the velocity, which for the usual shapes lies between $V^{-.08}$ and $V^{.12}$. This is equivalent to a variation with the quantity VL and is in accord with the dimensional theory. The resistance can vary as V^2 only when it is due to eddy-making. Good stream-line forms have a minimum of eddy-making resistance combined with a relatively large amount of skin friction. In fact, for seven models of very different shapes, representing seven actual airships, the skin friction as computed by Zahm's formula

$$R_s = 00000778bL^{\cdot}V^{\cdot}$$

is from 79 to 93 per cent of the total resistance observed.

The ratio of resistance of a model to the resistance of a disk equal in area to its maximum cross section is known as the "disk-ratio," and it varies between 1/15 and 1/17 for good shapes.

The resistances as measured do not vary as V^2, but as some lower power. Individual models show exponents between 1.85 and 1.92.

Yawing moments about the center of volume, as determined for several models, indicate practically no difference at small angles. It appears immaterial what form of bow or stern is used, within reasonable limits.

The shape of the mid-body has the most important effect on resistance. Bow and stern are less important. A parallel mid-body is disadvantageous, an added length equal to one diameter may increase the resistance 15 per cent.

The form of the bow is slightly more important than the stern. A pointed nose can be replaced by a rounded one of good shape without change in resistance. A long, fine or conical tail is worse than a shorter, rounded one of easy curvature. The most advantageous fineness ratio appears to be between 5 and 6.

The above notes apply only to good forms. The forms vary in resistance, depending on shape, not more than 8 per cent above or below the average for the series.

German Development in Rigid Airship Design

(c) Keystone View Co

Forward Car of the Zeppelin Liner Bodensee, Housing the Navigation Room, the Radio Cabinet and a Cabin for Twenty-Five Passengers

The Goodyear Automatic Gas Valve

By A. G. Maranville

Aero Design Dept., The Goodyear Tire and Rubber Co.

The following summary of the practical features of the Goodyear automatic gas valve is a result of several months experience and includes all the minor improvements made up to this time.

Pressure Adjustment.—The adjustment of the pressure on this valve requires no tools whatever for adjusting, a knob being carried to the outside of the valve dome giving perfect accessibility and allowing the valve to be adjusted between limits of 20 and 60 mm. (with the standard springs).

Ball Bearing Joints.—Since friction increases the pressure limits between which the valve opens and closes, it is self evident that a sensitive valve which works in such low pressure limits as required should be as frictionless as possible. All moving joints in this valve are equipped with ball bearings to reduce this friction to a minimum which also eliminates considerable attention after installation.

Roller Bearing Stem.—To further reduce the friction on the valve the stem of the valve is equipped with adjustable roller

Goodyear Valve, Closed, with Its Gasket and Cover

bearings which also minimizes the friction in the valve and prevents the possibility of the stem binding due to wind resistance on dome or irregular forces.

The Decreasing Spring Tension.—One of the most important duties of an automatic gas valve is the maintenance of a constant volume in the gas bag at a constant pressure. The ordinary type cannot attain the constant volume and pressure since the spring tension actuating the valve increases as the valve is opened. In the Goodyear valve the lever system is so designed that it gives a decreasing tension on the valve which results in a maintenance of the constant volume and pressure in the balloon.

Emergency Closing Device.—For safety of airship operation an emergency closing device has been developed on this valve to prevent the possibility of its sticking open. The necessity of this device may be easily seen and its effectiveness and simplicity of design has been amply proven. The positive closing cord as now furnished is distinct from the opening cord, but a combination device which combines the two functions in one cord has recently been tried with success.

Attachment Gasket.—The valve is attached to the envelope by a special molded gasket which insures a good fit. A very simple clamping ring with wing nuts is used to hold the valve in place.

Weight of Valve.—The weight of the valve is approximately 16 lb., which is no less than is consistent with good design.

Leakage.—The leakage on the present valve has been reduced to less than 1/100 of one per cent of the volume of a 100,000 cu. ft. envelope per day.

Resistance to Weather.—The ball and roller bearings which are coated with grease meet all weather conditions, especially corrosion. In addition the use of a pair of rubber gaskets (rubber against rubber) prevents any possibility of the valve freezing shut due to sweating of the metal on the gasket.

Gaskets.—Two lip type gaskets are used in this valve, which make it very sensitive on opening and closing, in fact very little pressure is required on the dome to hold it shut, for the lips of the gasket form a natural seal themselves. The double lip gaskets also account for the extremely low leakage in this valve.

Static Wiring.—Great care is taken to positively connect all parts. This connection between the clamping ring and inner frame is insured by the wing nuts and bolts. Between the dome and frame a flexible wire connection is made before the valve leaves the factory.

Performance.—In actual service the Goodyear automatic valves have proven far more satisfactory than any other type of automatic valve which has been so far developed. For

Goodyear Valve, Open

example one may quote from a letter from Lieutenant-Colonel Jouett covering a report on the Army Airship A-4. "The functioning of the valve is easier and more positive than any other valve. In functioning the valve opens wider and closes quicker as a greater volume of gas is let out in a shorter time. The adjustment of the valve is very simple, requiring no tools. If the valve is wanted to function at 1½ in. pressure it will function at that pressure and close before the pressure drops much below that which it is set for, whereas other valves go below and quite often stick open."

S. A. E. Aeronautical Meeting

The Society of Automotive Engineers will hold on March 10, 1920, at 2 p. m., in the Engineering Societies Building, 29 West 39th Street, New York, an aeronautical meeting at which various papers dealing with aeronautics and aircraft design will be read.

The tentative program is as follows:

Possible Airplane Performance with Maintenance of Engine Power at all Altitudes, by Col. V. E. Clark.

Consideration of Landing Run and Getaway by Standard Type Airplanes, by Alexander Klemin.

Effect of General Shape of Aviation Engines on Operation of Airplanes, by Grover C. Loening.

Some Factors in the Design of Airplane Radiators, by S. R. Parsons.

The Heat Treating of Brazed Fittings for Aircraft, by Archibald Black.

Flying an Aviation Engine on the Ground, by S. W. Sparrow.

Invention in Aeronautics*

By Frederick W. Barker

From time immemorial we have had vessels that could float on water because the density of that medium permits buoyancy, and the air also was found to give buoyant support since the days of the hot air balloon, but the real conquest of the air came only when a controlled airplane was caused through speed of its movement to convert the tenuous atmosphere into a weight sustaining medium.

Of course it is the internal combustion motor which rendered possible the flying machine, and we have to thank the automobile industry and the engineering profession for the numerous refining influences they brought to the motor and thus gave the airplane its opportunity to come into being. But it must not be overlooked that the automobile motor has also proven the most serious handicap that aviation has had, simply for the reason that we have sought to apply to a new, more arduous duty an instrument that had been perfected along lines suited only to an older and less difficult task.

Invention has still its most important field in the production of a thoroughly reliable aviation power plant, and this will come through designs providing sturdy construction wherein the weight is kept within bounds, with more efficient temperature control, continuous and thorough lubrication, an ignition system that can be absolutely depended upon, and propelling means that will develop a maximum of thrust. Patents which improve these and allied features to help the power plant in the delivery of continuous high power output over an extended period will do more than anything else to advance the cause of commercial aviation. This progress will be gradual and tested out at every step. But inventors and aeronautical engineers must get completely away from the intermittent and low duty form of motor which is good enough for the automobile, and strive to meet the sterner conditions of a flight sustaining power plant.

The scope for inventive ingenuity in this field alone is as vast and the reward for success in every detail as sure and generous that its attraction is irresistible and will be responsible in the next few years for innovations which will easily differentiate the aviation motor from the automobile motor.

Invention also will show the way to take off an airplane without a starting run over the surface, and to alight and stop wherever desired. The natural forces to serve these ends are available, and even now are in process of harnessing.

Here and there will stand out some bold concept whose deviser may achieve more fame and receive greater emolument than others, but ancillary devices, marking various stages of development, will result as the contribution of many inventors who attack the problems involved from different points of view.

There was published last month in the Journal of the Patent Office Society a report by J. H. Colwell, one of the principal examiners in the Patent Office, of the more important subjects treated of by inventors, and this report, in so far as it relates to aeronautics, is so succinct and comprehensive that I am introducing Mr. Colwell's account in this paper.

It reads thus:

"The importance and the application of heavier-than-air craft to military purposes is obvious and self evident.

"The attention of the country immediately centered on this new form of vehicle, and it was natural that the minds of experts and inventors were directed to improvements in and devising new forms of airplanes, as well as to numerous related auxiliary devices, with the result that the Patent Office was flooded with applications bearing on aeronautical devices.

"There is believed to be no exaggeration in asserting that the advance in the development of heavier-than-air craft made during the past five years would have taken from fifteen to twenty years under normal circumstances, necessity is the mother of invention.

"In so far as the development of a practical machine is reflected in the Patent Office, no new principle or mode of air sustained flight appears to have been evolved. The airplane of the present day is based on the same principle and involves the general structure as first employed by the Wright Brothers in their successful air flight in the first decade of this century. Notwithstanding this, however, there is a wide gap between the aircraft of today and that of 1914 as regards the general efficiency, inherent stability, carrying capacity, motive power, controls and radius of action, as well as in various accessories, including instructional and training devices.

"The improvements show a general tendency to widen the range of use by anticipating larger load carrying capacity, necessitating increased engine power, and improved motor construction. Different types of modern planes are now equipped with engines ranging up to over 1,200 hp., including multiple engine units with reserve power.

"There is no reason to suppose that the limit has been reached, but, on the contrary, that air navigation is still in its infancy.

"Increased power calls for increased strength in frame construction without too great a sacrifice of lightness, as weight is a vital factor. This brought to the fore forms of bracing, struts and trussed wing beams. To overcome excessive wind resistance of exposed parts, which cause a useless waste of power and speed, attention was turned to fairing and stream lining all such parts, as struts, spars, engine housings, fuel tanks and radiator casings, as well as landing carriage frames. As at high speeds comparatively small areas exert by their wind resistance a greater relative detrimental influence, stream-lining the guy and brace wires has even been resorted to.

"To secure increased strength with the necessary lightness, resort is had to hollow metal tubing, but more generally to various forms of laminated wood framing, as embodied in struts, wing beams and ribs, as well as the fuselage and pilot's car itself. With methods devised and means of uniting and arranging the grain of wood laminae, it is possible to construct a wing rib lighter than one of steel of the same strength. Various materials, as aluminum and other metals, and compressed and treated fibrous structures are constantly being devised, as substitutes for linen in the supporting wings, and also, various substances and compositions commonly termed 'dope,' for treating the wing surfaces.

"The hulls and pontoons of hydro-airplanes and flying boats are constantly being increased in size and strengthened to make them more seaworthy in withstanding rough water, and the shock of alighting thereon. This has led to the creation of what might be considered a distinct branch in marine ship building, to some extent following the lines of the earlier hydroplane or speed boat. Increased strength necessitates the introduction of longitudinal and transverse hull framing, providing bulkheads for ballast and other compartments, analogous to that in ship building with variations to resist special strains resulting from the peculiar demands.

"A system of airplane construction which is being developed and particularly adapted to large craft, appears on its face, not only interesting, but plausible and practical, provided the location of the weight is not detrimental. Broadly stated, the system comprises a hollow plane merged into the fuselage so that the large trussed wing spars, the engine housings and fuel tanks, as well as the pilot, are enclosed within the lifting surface itself. The centre of the plane between the upper and lower walls is deep, while the wings taper to small depths towards the tips. The entire machine, including the pilot's car, is practically a part of the lifting surface, thereby necessitating comparatively few external wind resisting parts.

"Among other devices which are being continually received are detaching means for readily releasing bombs, mail bags and other articles, steering devices and automatic controls, wind pressure vanes for automatically regulating the speed, maintaining a constant angle of incidence and preventing the machine being pointed dangerously upward to exceed the critical angle and thus cause stalling, with a resulting fatal tail spin.

"Knock-down airplanes for ready transportation and assembling, telephone and telegraph accessories, and wind fans or mills for driving electric generators, and air and fuel pumps have received considerable attention.

*Excerpt from a paper read before the Aeronautical Society of America.

"The merits of a heavier-than-air craft capable of hovering in the air, or stopping in flight, and also of descending and rising vertically have been fully appreciated, both for military and other purposes. The advantages of such a machine are obvious; among them is the necessity of only a limited or small area of ground space for landing and launching. Numbers of machines designed to possess these qualifications have appeared, the most common type being the helicopter or horizontally rotating screw propeller for exerting thrust. Some of these have no lifting plane, relying solely on the helicopter thrust, while others propose to use the helicopter in conjunction with the ordinary airplane, and so to arrange the power transmission that the tractor or pusher propellers can be cut out and power applied to the helicopter, or both operated simultaneously.

"Although it appears that, as yet, no practical and successful machine of the above type has been evolved, it is by no means improbable that this problem will be solved in the future, in view of what has been accomplished and the great strides in development along these lines by keen minded men of mechanical experience.

"In view of the constantly increasing altitude being reached in air navigation, numerous systems are being developed for obviating the ill effects of the highly rarified atmosphere, both on the pilot and in the functioning of the motor. These comprise various arrangements for compressing air, including wind fans, or motors otherwise operated. Some utilize the exhaust of the main engines for driving a turbo-compressor. By this means, a constant supply of air at uniform pressure is received, which is automatically regulated in accordance with elevation."

It will have been noted from the foregoing report that the sphere of invention has already widened out to so extent that admits the thoughtful endeavor of experts in many avenues of research, and proves that the inventive world is surrounding aeronautics with an association of arts, which, while each borrowing from one or more older arts, is itself of special character, and all of these new arts are interrelated through the science of aerodynamics, to whose dominant influence all aeronautical arts must be subservient.

Though today, to the man in the street, there seems to be a lag in visible production of aircraft in America, that is only the surface view. The surest sign of the times is in the Patent Office, where inventions in the aeronautical arts already surpass in number those of many older arts. With invention rife, the meaning is that demand exists even though that demand is in as intangible form as invention itself. For invention springs from super-mentality, creating something new to satisfy an unprecedented condition.

Vision and courage only are needed in America to enable her to win commercial supremacy in the air—such vision and courage as the warring nations of Europe had in 1914 when they improvised, under fire, different types of aircraft for different military usages. True, expense was a minor consideration then, for the existence of nations was at stake.

The American inventor is doing his part in aeronautics, as he has ever done in other arts and sciences, enriching the world with new thoughts and ideas which need only application to crystallize into further development, and this is actually the epochal period when the judicious investment of money and business endeavor stand to realize the most glorious harvest that has ever been gleaned in industrial fields.

California "Tech"

The name of Throop College of Technology at Pasadena, Cal., has been changed to the California Institute of Technology. The trustees took this action in order to denote its transformation from a college of primarily local significance into a scientific school of national scope.

Recently the institution received two gifts of $200,000 each to form permanent endowments for the support of research in physics and chemistry, and $800,000 has been given for general maintenance on condition that the new endowment be increased by additional donations to a total of $2,000,000. Other gifts aggregating $380,000 have been received for the construction of new buildings, including physical and chemical laboratories, an auditorium and a laboratory for aeronautical research.

Problems of Winter Flying

The Post Office Department, as a result of its winter flying thus far this season, calls attention to a problem in aerial navigation resulting from the accumulation of ice on airplanes while in flight. It suggests that those who figure some day on rising with a fully loaded commercial plane to a height of 18,000 or 19,000 ft. to take advantage of the reported steady westerly winds, those who would operate a commercial airplane line in Canada, or who hope to fly through to Siberia; or even those who would endeavor to operate commercially in the winter in the northern half of the United States, consider the two following reports of pilots in the Air Mail Service on ships forced down through coating of ice while in flight, which

Curtiss R-4 Mail Plane Fitted With Skis for Winter Flying

are typical of a half dozen or more forced landings for the same reason during the January operations of the Air Mail between New York and Chicago.

Under date of Jan. 20, Pilot Farr Nutter, United States Air Mail Service, reports to Supt. McGrath of his Division as follows:

"Ship No. 106 was flown to Chicago by the writer Jan. 15, 1920, and landed in Grant Park. Shortly after leaving Bryan, Ohio, ship flew into cold rain and snow; result, ship collected ice during balance of trip and became very heavy. Was required to fly ship in stalled position to maintain altitude with motor fully open.

"Over Gary, Ind., the ship suddenly began vibrating, indicating that some brace wire had broken. Motor functioned perfectly. Continued flight to station and was landing at high speed (70-80 m.p.h.). Leveled off at 15 ft., cut motor, ship dropped, landed on three points. Broke two shock absorbers and four longerons. This damage was unavoidable, due to weakened fuselage before landing and overloaded ship with ice."

The plane clearly dropped like a plummet on leveling off for the landing on the slowing down of the motor.

Under date of Jan. 21, Pilot Clayton W. Stoner, of the Air Mail Service, reported on his flight and forced landings Jan. 16, 1920, between Chicago and Cleveland, saying:

"The day was very damp and misty and the mist froze to the wires and struts as fast as it struck. The wires soon became coated, the struts the same, the air-speed indicator filled with ice, and the machine finally refused to stay in the air with the motor turning over with maximum speed. I landed at a place near North Liberty, Ind., and kicked ice off plane. I took off, and, as before, the ice formed on the machine again and forced me down at a place near Millersburg, Ind."

Nature takes care of this condition in birds, and airplane designers and manufacturers should chalk this down as a point to consider when designing or building commercial aircraft for regular and dependable transportation.

Maintenance of Gas Purity by Purging

By R. H. Upson
Chief Aeronautical Engineer, the Goodyear Tire and Rubber Co.

By the term "purging" is usually meant replacing a certain portion of the gas in an airship envelope without entirely deflating it. With a liberal supply of gas it is a convenient method of maintaining a good lift at an expense in time of only a few minutes a day. Due to its obvious advantages the practice has become quite prevalent in this country, but perhaps without full appreciation of its disadvantages, which the indirect, are nevertheless very real.

Fortunately the subject is capable of a fairly exact mathematical analysis.

Let a = the average drop in purity per day, expressed in per cent.

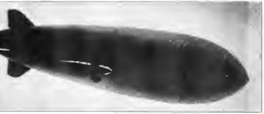
Let x = the per cent purity of the new gas as received from the generator or holder.

Let y = the per cent purity at or above which the gas in the balloon is to be maintained.

Let V = the actual total volume of the balloon (in cu. ft.)

Now let us further assume that 94 per cent is the purity at which we wish to keep the gas in the balloon. When the gas is first put in it is 98 per cent, so that nothing will have to be done at all until it has time to get down to 94 per cent, which will take, roughly, $4 \div 0.2 = 20$ days. At the end of that time if it is wished to maintain that purity by purging, a quantity of gas must be replaced equal to about 5,000 cu. ft. per day, over and above what is necessary to take care of ordinary outward diffusion. This, if continued for another 20 days, will make up an amount equal to the entire original volume of the envelope.

Suppose on the other hand that instead of starting to purge at the end of the first twenty days we had let all the old gas out and entirely reinflated with fresh gas. This same quantity of gas would again last twenty days before it got down to 94 per cent, but the average during that time would be, not 94 per cent, but 96 per cent. If it were wished to maintain



U. S. Naval Airship C-5 in Full Flight, Seen from Below

Let Q = the cu. ft. of fresh gas necessary to replace per day. Then it may be shown that:—

$$Q = \frac{a\ V}{x - y}$$

This formula is developed on the assumption that the full quantity Q of old gas is removed before any gas is put in, which is the most favorable condition. Q naturally includes any gas which is discharged from the valve or which escapes through any other mechanical openings. It does not include, except under special conditions, the gas which escapes by diffusion through the fabric, which must be replaced by an additional amount of new gas. It is not strictly accurate to ignore the effect of the outward diffusion in this way, but in most practical cases it works out fairly well.

As an example, suppose that V = 100,000 cu. ft., a = 0.2 per cent per day, x = 98 per cent, then

$$Q = \frac{20{,}000}{98 - y}$$

or as follows for different values of y:—

y (per cent)	Q (cu. ft. per day)
97.8	100,000
97.5	40,000
97.0	20,000
96.0	10,000
95.0	6,700
94.0	5,000
93.0	4,000

an average of 94 per cent by the reinflation method the period intervening between such reinflations could be just doubled, thus making it forty days on the average instead of twenty. (This is neglecting the progressively lower value of (a) for lower impurities, which however almost balances itself.)

A given quantity of gas would then go about twice as far by the method of reinflation as by that of purging. This one rule holds no matter what figures one cares to take, so it may be stated quite generally that *it takes twice as much gas to maintain a given average purity by purging as it does by reinflation.*

Against this must be balanced the other factors involved, to determine which method is really the best. For instance, the ship may be handled in such a manner or under such conditions that a large part of the gas necessary for purging must be replaced anyway, due to valving and other mechanical losses. This is especially true if there is no gas holder at the station to take up the ordinary fluctuations of volume while the balloon is in the hangar.

We must also consider the loss of time, the wear and tear on the bag and other complications incident to a complete change of gas.

In general, with an airship station planned for the purpose, the gas can be much more economically handled by the method of reinflation, but there are so many exceptions and special cases that it is impossible to give any general conclusion. The best that can be done is to keep in mind the main principles so as to figure out the proper procedure for any given set of conditions.

The Starting of Airplane Engines*

By T. L. Sherman, B.E.

With all internal combustion engines there exists the possibility of a backfire taking place. By this is meant that an explosion takes place before the crank reaches its out dead centre, with the result that the engine rotates in the direction opposite to that in which it is designed to run. Usually an advanced ignition is the cause. In high compression engines with large cylinders there is a big load on the piston due to compression which will cause a certain amount of backward rotation. The explosion backfire, however, is a serious matter, and is likely to damage the starting mechanism unless some means are provided to safeguard it. With the type of dog usually employed, the pressure from a backfire takes effect between the surfaces used for turning over the engine, and the throw-out mechanisms described above are therefore of no use as a check to reverse motion of the starting gear. If the whole explosion torque is transferred to the geared system, the impressed load is high and the gears will tend to rotate at a very high speed. We are not perhaps as much concerned with mechanical breakage when hand starting is used, as the gear system is usually simple, and the reduction ratio only of the order of 10 to 15 : 1. There is, however, considerable danger of injury to the operator by reason of the high speed of the handle and the suddenness of the backfires. With mechanical systems the gear ratio is usually much higher and the gearing more complete. When an electric motor is used the heavy armature is suddenly called upon to rotate at many thousand revolutions per minute.

Neglecting friction, the load required to accelerate the rotation of the gears and the remainder of the system at the desired rate is very high indeed. The geared system may be looked upon as a kind of friction brake under the momentary conditions. The results are high stresses in the dog projections and gear teeth with frequent failures. It is obvious, therefore, that we require in the gear system some safety drive which will safeguard the mechanism. Clutches of all descriptions and shear pins come to mind. Friction-operated clutches cannot be said to be satisfactory. They must be set in advance of the torque required to start the engine. As has been pointed out, one has to provide for very stubborn engines, so that there must be a good margin over the average.

Friction clutches are very uncertain, and great difficulty is experienced in setting them to work satisfactorily. This is in some measure due to the fact that designers have always in their minds the necessity for weight reduction and compactness, consequently the friction clutch is usually considerably restricted as to diameter and area; the fabric and the plate type are particularly referred to. The bearing pressures are high, and the friction coefficient somewhat uncertain. Metal-to-metal dog clutches of the type shown in Fig. 1 suffer from similar defects. One member of the clutch is driven through serrations on a diameter of the order of 1½in. to 2½in. Assume that the clutch is to operate at a torque load

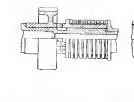


Fig. 1

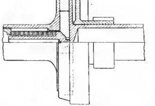


Fig. 2

of 5,000 lb.-in.—quite a reasonable figure. The load on the serrations at, say, 1in. radius will be 5,000 lb. Consider that five serrations divide the load equally between them, i.e., 1,000 lb. per serration. This is a rather optimistic distribution. In order to bring about axial movement against friction, 1,000 × .15 = 150 lb. approximately is required. The disengaging reaction which takes place between the clutch teeth has to overcome the serration friction as well as that of the spring. Moreover, the intensity of loading on the clutch teeth is high, and the proportional distribution of load an unknown factor. It will be seen that so long as these two factors are of the same order of magnitude the clutch is uncertain, as the spring pressure is not the deciding factor. Clutches of this type are all right where the torques are small, or where weight and size are not vital.

A clutch, designed by the writer, embodying similar principles is shown in fig. 2. Here the sliding members are plungers, case-hardened all over, ground to fine limits, and lapped into position to secure a free movement with the minimum amount of "tipping." The internal coned surface is ground with the inside flanges in position, the clutch member being held in a fixture. The flat tapered faces on the outside plungers are free to mesh correctly with the internal splines in the female member. The spring and its tapered attachment are not rigidly centred, so that the tendency for one plunger to take the full load is minimized. It constitutes, in short, an attempt to minimize the friction of the sliding member.

The use of a shear pin as a safety device in the system is unsatisfactory. It is perhaps more certain in guarding against breakage than any type of friction-operated clutch, but it is difficult to arrange a design so that a new pin may be fitted quickly. This requirement (a new pin) is in itself

*From *The Automobile Engineer*

a weak feature. It may have use as a secondary safeguard in combination with a clutch. Systems have been schemed which arrange for a mechanical release when reverse rotation takes place. These usually rely upon some pawl arrangement, simple or complex in its design. One form is indicated in fig 3. Here we have an oscillating member which takes no part in the transmission of the load. In the direction of the engine's normal rotation, this member (A) is driven by the gear wheel (C), and is free to oscillate as determined by the tapered side of the projections on (D). If a reverse rotation takes place, (D) prevents the rotation of (A), which, in its turn, pushes (C) out of mesh. The system is positive and operates successfully, but it requires a certain amount of movement to take place before it brings about the required disengagement. It should be placed on a shaft having a speed, say, ten times that of the rate of rotation of the engine-shaft produced by the backfire, so that release will be brought about quickly. In a hand-operated system it may conveniently be placed on the handle shaft.

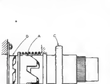


Fig 3

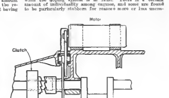


Fig 4

Hand-starting gear boxes usually provide for a speed reduction of the order of 10 : 1. The handle shaft itself is usually arranged to come out at the side of the engine, thereby necessitating the use of gears of the worm, bevel, or spiral type. It is easy to secure the required reduction with a worm and worm wheel alone.

Unfortunately, this form of transmission has a poor efficiency in the low speed of operation of the handle shaft, say 15 r.p.m. One cannot very well have a bevel pinion less than 1in. p.d. This would necessitate a 10in. bevel wheel—a size too large to be neatly installed; consequently we find bevel gear transmission with a supplementary set of spur gears. The same remarks apply to spiral gears. The efficiency of these double trains under operating conditions is probably 25% better than that of the worm gear. There is perhaps nothing to choose between any particular system on the score of weight. A complete hand-starting gear for a 400 h.p. engine should not weigh more than 10 lb. The only real drawback to the system is that it is not suited for remote control, and requires that a mechanic should stand on the wing or platform in order to turn the handle. With a good doping system and a hand-starting magneto, starting is comparatively easy. In twin-engined machines the handle shaft may extend out at the rear of the engine in the same direction as the crankshaft. It may then be turned by a mechanic standing on a portable platform. The writer considers this arrangement inferior to that already described. Frequently one finds that the length of handle arm fitted is much too small—sometimes not greater than 8in. Nothing under 12in. should be fitted unless there is a very special reason for the use of a smaller handle.

Compressed air has been used to a considerable extent for engine starting, the system being to employ a steel bottle containing a charge of compressed air. Each cylinder is fitted with an air valve of the non-return type, which is connected up to a mechanical distributer usually driven from the camshaft. The distributer is connected through a reducing valve to the air bottle. The distributer may be of the poppet, sleeve, or disc valve type, though the first-named cannot be said to be entirely satisfactory. It has been found possible to start engines of 250 hp. with air at 100 lb. per sq. in. A bottle weighing 15-18 lb. is usually capable of producing four separate starts. The total weight of distributer pipes and adapters is of the order of 10 lb. This would indicate a complete starting equipment for one engine to weigh under 30 lb. It should be possible to provide for twin engines at 35 lb. to 40 lb. The small number of starts provided by the air bottle is a disadvantage, which is more particularly felt when the doping system is at fault. There is a certain amount of individuality among engines, and some are found to be particularly stubborn for reasons more or less uncontrollable. Generally, however, it must be said that the system compares favorably with any other so far developed. Its limitations, however, are obvious, and in its present form it can hardly persist.

Instead of using a reservoir filled by external means remote from the airplane, some form of power unit may be installed in the machine which can supply the necessary quantity of air at the required pressure. But why not go a step further? Make the pumping apparatus supply mixture to the engine, not air. This will do away with the more primitive and inefficient methods of doping, and at the same time supply the means for turning over the engine. At the present time such a system is under trial, though in a form which the writer considers scarcely correct. One of the cylinders of a horizontally-opposed motor cycle engine has been supplanted by a specially designed pump cylinder. This cylinder compresses mixture drawn from the carburetter of the small engine and supplies it through a distributer on the main engine to the cylinders thereof. This is ingenious, in that it supplies a correct mixture as determined by a carburetter working under normal conditions, but it is deficient, in that it does not ensure that a correct mixture reaches the engine. It is usually difficult to arrange for the mounting of such a unit close to the engine, and condensation will take place to a considerable extent in the small bore piping used. The pump should supply air alone, which should take up the fuel at some point adjacent to the distributer on the engine. The fuel supply to the distributer may be controlled by the pressure of the air against a spring-controlled valve. Preferably this carburetter-distributer unit should be heated electrically, the latter offering practically the only means of conveniently arranging remote control. Electrical heating apparatus is practically standardized nowadays for large machines. A pump unit specially designed for the purpose can probably be made under 50 lb. weight. This is on the high side for single-engined machines of 400 hp., but is a perfectly feasible proposition for machines with two or more engines. The starting handle of the pump engine should be located in a convenient position for the pilot or observer. A unit mounted on an aerodrome runabout is an ideal method for starting engines

suitably equipped. The writer considers that the scheme outlined herewith offers the most efficient solution of the starting of large airplane engines so far devised. The pump should be capable of supplying air at 100 lb. per sq. in., and have sufficient capacity to turn the engine over at six to ten revolutions per minute. At this speed a starting magneto will be required, but coil ignition will in itself be found satisfactory.

Another form of air starting apparatus has been used. Instead of supplying the air to the engine cylinders, the air bottle is connected up to a separate cylinder having a piston attached to a rack and gear wheel mechanism. The pressure applied to the piston causes motion of the rack and consequent rotation of the gear wheel. The gear wheel is mounted on the "dog" shaft. The mode of operation is obvious. For a given air pressure the torque applied is proportional to the diameter of the gear wheel. Generally it will be found that this diameter is such that only a partial revolution of the crankshaft is obtained for a stroke of the piston. Another construction is to attach a wire or chain to the piston. The wire or chain is wrapped round a wheel similarly positioned to the gear wheel above. The use of a wire enables the use of devices to safeguard against backfire, it being less rigid than a rack and gear. Continuous rotation is usually not obtainable. As the pressure in an air bottle falls off quickly in use, it will be appreciated that the maximum torque developed will go off in like proportion, and so each start will be less effective than that preceding it.

It has been proposed to use a liquid such as compressed carbon dioxide, which will not only provide the required pressure at atmospheric temperature, but will also increase the capacity of the bottle considerably. The pressure will remain practically constant within limits. There is much to be said for the idea. One objection is that the agent is not combustible, and so cannot be used in conjunction with a special carburetter to provide the mixture as well as the moving force.

Explosive charges were at one time experimented with in order to replace the comparatively heavy air bottle of limited capacity. Cartridges were inserted into a breech, and upon combustion were to supply a sufficient quantity of compressed gas to start the engine. There are obviously two ways of using explosive charges. One method is to insert the cartridge into a special fitting attached to the cylinder head and detonate by some suitable mechanism. On a six-cylinder engine it was usual to employ three cartridges. The cartridges were of 12 bore, and were charged with black powder. This system was not used to any extent. The other method is to employ a separate chamber in which a number of charges are fired in rapid succession. Although it is reported that the pressure within the chamber rose to 350 lb., the crankshaft did not move sufficiently to start the engine. The deposit from these cartridges was excessive, and the distributer quickly became blocked up. It is considered that the use of cartridges can only be satisfactory when connected directly to the combustion chamber of the engine, as the cooling effect of the tortuous passages through the distributer and piping system brings about a great falling off in the pressure of the products of the explosion. The system is uncertain and not suited for remote control.

The employment of an electric motor and a reduction gear has of late received a considerable amount of attention. For a complete system it is, of course, necessary to carry a storage battery in the airplane. This battery is required to fulfil severe conditions as to discharge. A 12 volt battery is frequently called upon to supply a current of 200 amperes for periods up to one minute. Owing to the fact that it is desirable to use the battery for other electrical services besides engine starting which do not require such excessive discharges, there is a tendency more or less to neglect the features required by a starting battery. One usually finds that when the battery is discharging at 150 to 200 amperes, the volts fall considerably, frequently as low as 8. It is not possible to get good starting below 8 volts, the system being nominally 12 volts. The labor available for charging batteries at the various aerodromes during the war was by no means first class, and some of the poor results obtained may be attributed in a large degree to it. Batteries, to give good service, must be intelligently cared for. This is, of course, one of the demands of a self-contained electrical system which may be regarded as a defect. It must be said that American batteries built for starting purposes have proved much better than British ones from this point of view. The quantity of acid in the accumulators is usually too small. If electrical starting systems are to attain success, the battery makers will have to evolve improved products, as the whole system depends fundamentally on the battery.

It will be admitted, however, that the battery designer is usually asked to fulfil conditions which are brought about by the inefficiency of the remainder of the system. The starting current required is dependent on the combined efficiencies of the motor, a gear box, and doping system. The latter has been referred to previously, but it would be as well to repeat that the demand upon the starting mechanism depends

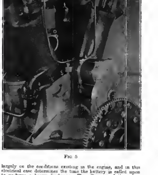


Fig 5

largely on the conditions existing in the engine, and in this electrical case determines the time the battery is called upon to undergo a heavy discharge. The efficiency of the motor is a factor that we can control to a certain extent, though it is bound up with the question of weight. A motor capable of giving a torque of 2 lb.-ft. at 3,000 r.p.m., 4 lb.-ft. at 1,500 r.p.m., with a "lock" torque of 6 lb.-ft., has been developed with a weight of 10 lb. Its electrical efficiency varies considerably with the speed. At 2 lb.-ft. it is 50 per cent, at 4 lb.-ft. about 40 per cent. This is, of course, low, but is brought about by the restrictions on the design of the motor. Another motor with a weight of 15 lb. gives 3 lb.-ft. at 3,100 r.p.m. Combined with a gear box embodying two speed reductions (115 : 1), the efficiency was 54 per cent at 3,000 r.p.m., falling to 32 per cent at 4,000 r.p.m. Electrical starting arrangements have usually been afterthoughts in the past, and, whereas an efficient gear reduction could have been provided for when the engine was projected, the attachment generally met with has been designed under considerable restrictions as to space available, and generally suffers from the efficiency standpoint. Worm gears are particularly bad in this respect, and the writer has yet to find an efficient one in a starting mechanism. The speeds and loadings are high when efficiency is demanded. Epicyclic constructions are likely to be satisfactory if properly carried out, but unless special care is taken in manufacture and assembly they may prove very much the reverse. It must be remembered that reductions of the order of 100 to 150 . 1 are called for by large engines. An efficiency greater than 70 per cent at full peak load can hardly be expected. The great majority of gear boxes so far used return much nearer 50 per cent It will be seen, therefore, that the starting battery is required to provide for this inefficiency of motor and gearing

The writer is of opinion that if electric starting is to have wide application for airplane engines it will have to be embodied by the engine designer in his engine. For V engines the most suitable position for the electric motor is at the front of the engine mounted on the crank case between the

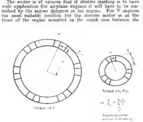


Fig 6

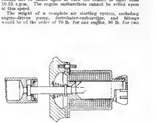


Fig 7

first pair of cylinders. It will then be possible to have a double train of spur gearing within the nose of the engine The scheme is outlined in Fig 4 If the motor is mounted on the nose itself, it interferes with space required for the radiator. Otherwise this position is good, because it allows the torque to be transmitted via the propeller boss flange Fig 5 indicates the arrangement referred to An installation at the rear of the engine is inaccessible, and its design is frequently restricted by water pumps and engine mounting members.

The writer considers that a motor gearing and necessary housings can be provided for a 400 hp V engine at a combined inclusive weight of 16 lb A battery weighing 30 lb will give satisfactory results in a single-engined machine The battery should be mounted as closely as possible to the motor, otherwise the C.R. drop will be excessive This begs the question as to whether one central battery or two separate batteries will be required for twin-engined machines There is little to choose on the score of weight. If one battery is used its weight will be of the order of 40 lb, with a further 10 lb. to 15 lb. weight of copper bar connections if the resistance losses are to be kept within reasonable limits The position of the battery in respect to wiring is not so important for the other electrical services

The remarks previously made with regard to the reversal of the mechanical system in event of a backfire, apply very particularly to the electrically-driven mechanism We are concerned with a comparatively heavy armature geared up at 100 to 150 1 A little calculation will show that practically the whole of the explosion torque load will be thrown on the driving dogs and gear teeth The loading is particularly high on the driving dogs, as they are usually on the low speed shaft Every endeavor should be made to make the radius arm of the projections on the driving dogs as large as possible, and so decrease the magnitude of the load to be carried by them Fig 6 indicates what is meant. Similar remarks as before apply to mechanisms for dealing with the reverse loading.

It may be mentioned that a most convenient method of bringing the starting dogs into mesh when required is to connect the sliding starter shaft to a solenoid, wired in series with the motor, and operating against a spring as indicated in fig 7 Various interlocking devices may also be arranged.

It will be seen, therefore, that complete electrical starting equipment for one engine may be fitted for a weight of 45 lb to 50 lb.; for two engines 80 lb. to 90 lb Ten to twenty pounds of this weight may be legitimately subtracted if the other electrical services use the same battery, but this may be discounted by reason of the necessity to provide a separate doping system to ensure easy starting. The electric motor should not be called upon to turn the engine at more than 10 15 r.p.m. The engine carburetters cannot be relied upon at this speed.

The weight of a complete air starting system, including engine-driven pump, distributer-carburetter, and fittings would be of the order of 70 lb for one engine, 80 lb for two engines. The electric starting system compares favorably for single-engined machines There is little to choose for twin-engined machines, whilst for three or more engines the air system previously outlined is probably most suitable. The advantages of one system over another from the weight point of view are not very definite, and individual cases of careful design may turn the issue one way or the other

The writer is aware of the fact that there is considerable opposition to the use of electric starting systems on airplanes with possibly a fair amount of justification. It must be admitted, however, that no really serious attempt at the problem has yet been made

With the development of large engines of 600 hp. to 1,000 hp, the starting proposition becomes a real one, and it behooves engine designers to study the question, embodying the starting system in the engine, than saving the innumerable troubles which crop up afterwards. The matter should receive the same thoughtful consideration as any other important part

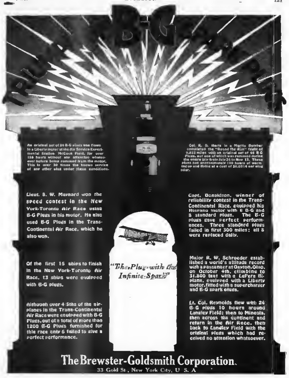
Book Review

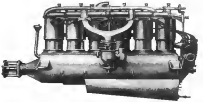
Future of Aviation. Translated from the French by Jean Dargon by Philip Nutt. (174 pp Illustrations and many diagrams)

While this book bears a rather unfortunate title, which would seem to place it in the class of prophetic and therefore dangerous books, it is written in a very sound and conservative way

An aerial postal service is discussed with very sensible figures on initial cost and running and depreciation costs The chapter on aerial touring is interesting. The one on colonial aviation has some useful ideas as to what can be done in sparsely populated countries by means of the airplane. The chapter on the establishment of an aerial line also has references to the French colonies, but it will be useful in analogy to American readers interested in transportation

There is a description of international air lines covering the entire world A great deal of meteorological and other technical information is included. Mr. Dargon seems to have struck the happy medium between too conservative an outlook and too optimistic a one


An original set of 24 B-G plugs was flown in a Liberty motor at the Air Service Experimental Station McCook Field, for over 155 hours without any attention whatever before being removed from the motor. This is over 30 times the known service of any other plug under these conditions.
Col. R. S. Hartz in a Martin Bomber completed the "Round the Rim" flight of 9,823 miles with an original set of 48 B-G Plugs, not one of which was removed during the entire trip from July 24 to Nov 13. These plugs had approximately 140 hours of warming up and flying at a cost of $0.0214 per plug hour.
Lieut. B. W. Maynard won the speed contest in the New York-Toronto Air Race using B-G Plugs in his motor. He also used B-G Plugs in the Trans-Continental Air Race, which he also won.
Capt. Donaldson, winner of reliability contest in the Trans-Continental Race, equipped his Hispano motor with 8 B-G and 8 standard plugs. The B-G plugs gave perfect performances. Three standard plugs failed in first 300 miles: all 8 were replaced daily.
Of the first 15 ships to finish in the New York-Toronto Air Race, 13 ships were equipped with B-G plugs.
"The Plug with the Infinite Spark"
Major R. W. Schroeder established a world's altitude record with a passenger at Dayton, Ohio, on October 4th, climbing to 31,800 feet with a LePere Biplane, equipped with a Liberty motor, fitted with a supercharger and B-G spark plugs.
Although over 4/5ths of the airplanes in the Trans-Continental Air Race were equipped with B-G Plugs, out of a total of more than 1200 B-G Plugs furnished for this race only 6 failed to give a perfect performance.
Lt. Col. Reynolds flew with 24 B-G plugs 10 hours around Langley Field; then to Mineola, then across the continent and return in the Air Race, then back to Langley Field with the original plugs which had received no attention whatsoever.
The Brewster-Goldsmith Corporation.
33 Gold St., New York City, U. S. A.



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